## 7.11 Soil contaminants

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**Citation for this chapter**: Cavanagh, J. (2024). Soil contaminants. *In:* Lohrer, D., et al. *Information Stocktakes of Fifty-Five Environmental Attributes across Air, Soil, Terrestrial, Freshwater, Estuaries and Coastal Waters Domains*. Prepared by NIWA, Manaaki Whenua Landare Research, Cawthron Institute, and Environet Limited for the Ministry for the Environment. NIWA report no. 2024216HN (project MFE24203, June 2024). [https://environment.govt.nz/publications/information-stocktakes-of-fifty-five-environmental-attributes]

Alternative attribute name: Trace element contaminants in (residential) soils

**Preamble:** Trace elements occur naturally in the environment with concentrations in soils dependent on geological and pedological processes. There are many anthropogenic activities that resulting in the release of trace elements to soil including various industrial and agricultural processes, fossil fuel combustion, waste disposal process and residential use.

The term ‘heavy metals’ is most often intended to be used to describe metal *and* metalloid elements that are considered to cause deleterious effects. However, this is a technically inappropriate term as not all metals and metalloids are heavy nor do they all cause deleterious effects – the latter is more dependent on the concentration at which the metal and metalloid elements occur. For example, zinc and copper can be considered heavy metals but they are also essential micronutrients required for plant and animal growth. At low soil concentrations they may be deficient for some plant and animal species, while at higher concentrations can become toxic.

A more appropriate term might be trace element contaminants, to encompass both metal and metalloid elements and providing a focus on when the trace elements may become contaminants/present as elevated concentration that results in deleterious effects.

The common suite of contaminant elements includes arsenic, cadmium, chromium, copper, lead, nickel, mercury (variably), zinc.

This information stocktake was constrained to a focus on metal and metalloid (trace element) contaminants in residential soils.

**State of knowledge of the “Soil Contaminants” attribute:** Good / established but incomplete – general agreement, but limited data/studies. Reasoning is that it is established that elevated trace element concentrations can occur on residential soils, but there isn’t comprehensive coverage of residential soils across. There is excellent/well established information (globally) that elevated concentrations can cause human health or environmental effects but there poor / inconclusive information that trace elements in residential soils have negatively impacted on human health or ecological receptors.

## Part A—Attribute and method

### A1. How does the attribute relate to ecological integrity or human health?

Heavy metals in residential soils relate to both ecological integrity and human health. There is comprehensive discussion and assessment of the effects of a range of 'priority contaminants' for human health in [1, 2], and ecological receptors in [3-5] and references therein. These documents provide an overview of the effects of different trace element contaminants on people [1] and soil biota (plants, microbes, invertebrates) [3] and establish guideline values to indicate concentrations to indicate concentrations at which exposure might need to be managed to avoid negative effects [2, 4]. Further considerations in relation to both human-health and ecological integrity for soil-derived contaminants is the potential for leaching into groundwater and movement into surface water systems.

There are many factors that influence the actual effect of the different trace elements– this includes the way in which people or ecological receptors are exposed to the trace elements, and the bioavailability of the soil-associated contaminant. Bioavailability in turn is influenced by soil properties such as pH, soil carbon content, cation-exchange capacity [e.g., 6] and can also be directly assessed through different extraction processes designed to simulate release of trace elements [e.g., 7] from ingested soil particles, or weak-acid extraction to provide an indication of the availability of trace elements to plants [e.g., 8]. However, the specific bioavailability to plants and other soil organisms will also differ between species, and different species have different sensitivities to different trace element contaminants [e.g., 3].

Arsenic and lead are typically of greater human health concern i.e., soil contaminant standards for protection of human health are lower than ecological soil guideline values, while copper and zinc are typically of most concern for ecological receptors (in soils and water)[1,3].

### A2. What is the evidence of impact on (a) ecological integrity or (b) human health? What is the spatial extent and magnitude of degradation?

There is evidence of soil contamination from a plethora of site investigations that have been undertaken for the purposes of managing contaminated land under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS) [9]. These investigations occur on sites where an identified Hazardous Activity or Industry [10, 11] is likely to have occurred and typically where subdivision or a change in land use is proposed. These investigations determine the extent to which remedial action is required to inform its future use. Where remediation has been undertaken, site validation reports are to ensure remedial action has been effective to make the site 'safe' for use – in terms of protection of human health. While there is a regulatory requirement under RMA section 31 for territorial authorities to prevent or mitigate any adverse effects of the development, subdivision, or use of contaminated land', the existence of the NES-CS, which is for the protection of human health, and the general expectation that environmental issues fall into the remit of regional councils there is effectively no regulatory requirement to consider protection of ecological receptors [12] although this may vary between different councils, and some consultants will also consider this. The individual reports are held by different councils with no ready ability to collate the data.

As noted, the NES-CS only applies at the point of subdivision or land use change – with land likely to become residential property relevant for this attribute. Specifically, the NES-CS doesn't allow for the assessment of land not undergoing change, but which may be contaminated i.e., has been identified as a property on which a Hazardous Industries and Activities List (HAIL) activity has, or may have, occurred [12]. Regional Council have the responsibility to undertake the investigation of land for the purposes of identifying and monitoring contaminated land (RMA 1991 s.30(1)(ca)). However, further site investigation is required to determine if the site actually has concentrations present at concentrations of concern.

Beyond this, regional council state of the environment monitoring, which includes assessment for trace element contaminants, provides information on concentrations in agricultural land, which may then be sub-divided for residential use. A particular issue is associated with the sub-division of agricultural land, which may have cadmium concentrations above the rural residential soil contaminants standard [2, 13].

**A3. What has been the pace and trajectory of change in this attribute, and what do we expect in the future 10 - 30 years under the status quo? Are impacts reversible or irreversible (within a generation)?**

This is unknown as there has been no regular monitoring over time. In the context that there is greater awareness of the potential for contamination associated with various anthropogenic activities, and that resource consenting processes are intended to prevent soil from being contaminated, then future contamination of residential soils should be minimal and it is more a case of managing legacy contamination.

**A4-(i) What monitoring is currently done and how is it reported? (e.g., is there a standard, and how consistently is it used, who is monitoring for what purpose)? Is there a consensus on the most appropriate measurement method?**

No regular monitoring of this attribute is currently undertaken in New Zealand, although as noted in A2 there are numerous site investigations that have been undertaken for the purpose of managing soil contamination for the protection of human health, but there is a gap for residential properties that don't trigger the NES-CS.

There is guidance in contaminated land management guideline #5 [14] for undertaking site investigations, although this doesn't specify methods used for analysis of soil. However, the National Environmental Monitoring Standard for soil quality and trace elements [15] does specify the standard method for determining total 'recoverable' concentrations. Some information on bioavailability testing relevant for human health is provided in [16].

**A4-(ii) Are there any implementation issues such as accessing privately owned land to collect repeat samples for regulatory informing purposes?**

There would undoubtedly be issues as access to private properties would be required to fully assess the state of this attribute. However, under the current regulatory regime there is a gap in the requirement to assess residential properties that are not undergoing sub-division or land use change [12].

**A4-(iii) What are the costs associated with monitoring the attribute? This includes up-front costs to set up for monitoring (e.g., purchase of equipment) and on-going operational costs (e.g., analysis of samples).**

The cost of analysis of a soil sample for a trace element 'contaminant' suite, is generally around $80-$90 per sample based on total recoverable concentrations.

A simulated gastric extraction of arsenic and lead is also commercially available at Hill Laboratories for around $160 / sample with an additional set-up fee. This test gives some indication of the bioavailability of these trace elements from ingested soil.

Some bioavailability testing relevant for plants is available commercially, although these tests (e.g., melich-3, edta extractions) are typically undertaken to inform trace element fertiliser rather than assessing potential toxicity.

Further costs are incurred through the collection of samples – which will be determined by the number of sites, how sampling is undertaken at each site, including the number of samples and the depth of samples.

### A5. Are there examples of this being monitored by Iwi/Māori? If so, by who and how?

Māori have high interest in rehabilitating or remediating areas and sites considered contaminated or degraded [3]. However, we are not aware of specific monitoring being carried out by representatives of iwi/hapū/rūnanga.

### A6. Are there known correlations or relationships between this attribute and other attribute(s), and what are the nature of these relationships?

There is some relationship of trace element concentrations in residential soils to other soil domain attributes, specifically:

- Soil carbon,
- Contaminants in surface water, groundwater, sediment and air, and
- Erosion.

However, the nature of these relationships is highly variable depending on the individual trace elements of concern, the specific location and soil characteristics. The bioavailability of contaminants in soils depends on various soil properties including soil carbon content. The movement of soils with elevated concentrations into aquatic systems e.g., through erosion, or the leaching of contaminants into groundwater, can contribute to elevated concentrations in water and sediments. Resuspension of the contaminated soils (e.g., those containing lead, arsenic or cadmium) could contribute to their presence in ambient air.

## Part B—Current state and allocation options

### B1. What is the current state of the attribute?

The current state is partially known. As noted in A2, there are a multitude of site investigations and site validation reports for land that is subdivided and/or will become residential properties. These sites will be 'safe' for people as required by the NES-CS, although risks to ecological receptors may still arise. As also noted in A2, there is limited knowledge of the state of residential soils that haven't undergone land use change, but where a Hazardous Activity or Industry has, or may have occurred.

**B2. Are there known natural reference states described for New Zealand that could inform management or allocation options?**

Yes and no. Naturally occurring soil concentrations provide one form of a natural reference state and have been determined at a national level [17]. However, a focus on background soil concentrations in the context of managing soil contamination is a significant driver for the excess disposal of soil to landfill [12, 17-18]. Rather than focussing on background concentrations, more attention should be directed to managing the risk associated with elevated soil contamination, which includes using additional information such as the bioavailability of contaminants, to refine risk assessments [16].

**B3. Are there any existing numeric or narrative bands described for this attribute? Are there any levels used in other jurisdictions that could inform bands? (e.g., US EPA, Biodiversity Convention, ANZECC, Regional Council set limit)**

Yes. Soil contaminant standards have been developed for the protection of human health in the New Zealand regulatory regime [2]. Similarly, ecological soil guideline values have also been developed for use in a New Zealand context [4]. These soil guideline values provide useful information to help screen the potential risk associated with contaminant concentrations but further information, including the use of bioavailability assessment should be used to inform appropriate management approaches.

**B4. Are there any known thresholds or tipping points that relate to specific effects on ecological integrity or human health?**

From toxicological data there are various thresholds that have been identified as leading to different effects on people as well as ecological receptors [1, 3], and leading to the development of soil guideline values that can be useful to screen for potential risk to human health or environment [2, 4].

**B5. Are there lag times and legacy effects? What are the nature of these and how do they impact state and trend assessment? Furthermore, are there any naturally occurring processes, including long-term cycles, that may influence the state and trend assessments?**

Yes. Some of the observed contamination is a result of historical activity, however, new contamination may arise from improper disposal of waste products e.g., legacy wastes, ongoing application of fertilisers (e.g., cadmium), fungicides (e.g., copper), and animal remedies (e.g., zinc for facial eczema treatment), disposal of wastes to land (e.g., wastewater application to land) e.g., [11]. A key point to note is that ongoing application of trace elements, which do not degrade, will lead to accumulation in soils [e.g. 13, 19], potentially to concentrations where negative effects may be observed.

**B6. What tikanga Māori and mātauranga Māori could inform bands or allocation options? How? For example, by contributing to defining minimally disturbed conditions, or unacceptable degradation.**

Māori have a keen interest in being involved in the management and rehabilitation of contaminated or degraded land [4, 16]. In addition to discussing this attribute directly with iwi/hapū/rūnanga, there is likely to be tikanga and mātauranga Māori relevant to informing bands, allocation options, minimally disturbed conditions and/or unacceptable degradation in treaty settlements, cultural impact assessments, environment court submissions, iwi environmental management and climate change plans, etc.

## Part C—Management levers and context

### C1. What is the relationship between the state of the environment and stresses on that state? Can this relationship be quantified?

Beyond naturally occurring concentrations of trace element contaminants, the primary factor influencing their concentrations in residential soils depends on how the land was used BEFORE it became a residential property e.g., [9,11]. This includes agricultural activities (e.g., cadmium, arsenic from sheep dips), industrial activities, and diffuse pollution such as lead from leaded petrol. See also section C2.

The significance of the concentrations present depends also on how the land is being used as residential property, and therefore the exposure pathways for residents and ecological receptors, e.g., whether vegetables and fruit-trees are being grown, whether chickens for egg production are present, whether it is high-density residential property, and therefore exposure to soil in minimised.

Some of these factors are considered in the current management of contaminated land, briefly outlined in C2.

### C2. Are there interventions/mechanisms being used to affect this attribute? What evidence is there to show that they are/are not being implemented and being effective?

#### C2-(i). Local government driven

#### C2-(ii). Central government driven

The management of contaminated land is required under the Resource Management Act (1991), and the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS) is the primary tool for managing trace element contaminants in residential soil, and more generally soil contamination. The NES-CS is supported by a User Guide [9], as well as a series of Contaminated Land Management Guidelines and other documents [14, 21-27] to support the assessment of, and management of information related to potential contamination. The Hazardous Industries and Activities List (HAIL) [10] provides a list of activities and industries that may lead to soil contamination, with additional guidance recently released to aid with the identification of HAIL sites [11].

However, the NES-CS only applies at the point of land use change, and thus doesn’t allow for the assessment of land not undergoing change, and which may be contaminated [12]. Potentially contaminated sites may be identified where regional councils have undertaken city-wide assessments to identify HAIL sites (given the Regional Council responsibility to undertake the investigation of land for the purposes of identifying and monitoring contaminated land (RMA 1991 s.30(1) (ca)). However, further site investigation is required to determine if the site actually has concentrations present at concentrations of concern.

Another key gap of the NES-CS is that it only applies to the management of soils for the protection of human health rather than also considering ecological receptors or aquatic systems (groundwater, surface water). However, many consultants and councils are starting to incorporate ecological soil guideline values in their detailed site investigations.

#### C2-(iii). Iwi/hapū driven

Iwi planning documents such as Environmental Management Plans and Climate Change Strategies/Plans may contain policies/objectives/methods seeking to influence managing contaminant outcomes for the benefit of current and future generations.

#### C2-(iv). NGO, community driven

#### C2-(v). Internationally driven

## Part D—Impact analysis

### D1. What would be the environmental/human health impacts of not managing this attribute?

Not managing this attribute would likely lead to environmental and human health impacts. However, focussing only on residential soils is likely to not be an effective means of managing soil contamination or the associated environmental and human health risks, as assessing residential land is effectively managing the symptoms, not the cause i.e.. contamination on residential properties is more often a result of legacy land use for previous non-residential purpose.

Perhaps a notable exception is lead. The most common source of lead contamination on residential properties is lead-based paint [27]. The management of the risk associated with lead also requires an assessment of the internal sources of lead e.g., internal lead-based paints, and the residential lead working group has highlighted the need for a cross-agency approach to the management of this issue [28]. Some residential activities such as the disposal of wood-ash, including wood-ash from the burning of treated timber, can give rise to hot-spots of contamination on a residential property.

For soils that are currently not contaminated, the most effective way of managing soil contamination is to minimise the accumulation of trace elements to concentrations that can cause negative effects, though managing any ongoing inputs to soil e.g., use of copper fungicides, zinc for facial eczema treatment [4].

### D2. Where and on who would the economic impacts likely be felt? (e.g., Horticulture in Hawke's Bay, Electricity generation, Housing availability and supply in Auckland)

The greatest economic impact associated with this attribute is arguably on residential property prices. The perception of contamination – arising from the identification of residential that has previously been used for hazardous activities and industries–gives rise to concerns around the potential impact on property prices although there is no evidence of this risk being realised. Property price impacts are the concern most commonly raised in public meeting when regional councils have undertaken city-wide HAIL assessment; concern around the potential human health effects arising from potential soil contamination are less discussed.

**D3. How will this attribute be affected by climate change? What will that require in terms of management response to mitigate this?**

The effects of climate change on this attribute are unclear. Increasing storm and flood events could result in the wider movement of soil that contains elevated concentrations of trace elements. At a more subtle level, changes in temperature and moisture regimes could influence changes in the bioavailability of the trace elements.

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